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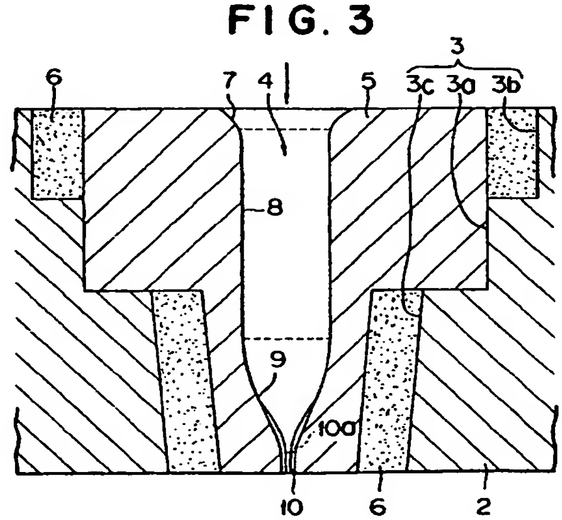
(54) Nozzle plate for spinning.

(57) A nozzle plate for spinning has a plurality of spinning holes (4), each spinning hole (4) comprising a fluid-introducing portion (8) and a fluid-discharging portion (10) having a small inner diameter from which molten fluid sent from the fluid-introducing portion (8) is discharged. At least a part of the inner surface of each spinning hole (4), which is connected to an entrance (10a) of the fluid-discharging portion (10), is formed as a three-dimensional smoothly curved surface (9) so that a form line of the entrance (10a) of the fluid-discharging portion (10) substantially does not appear. A portion causing residence of the molten fluid can be removed, thereby achieving an extremely smooth flow, and the pressure loss can be considerably suppressed.

FIG. 3



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The present invention relates to a nozzle plate for spinning, and more specifically to a nozzle plate for spinning which can prevent residence of fluid in the nozzle plate and reduce pressure loss due to the the nozzle plate.

Usually, a nozzle plate for spinning is manufactured by providing a number of spinning holes formed as a predetermined shape to a disc member made of a steel, particularly, a stainless steel. In a case where the cross section of a spun yarn is formed as a circular cross section, the spinning hole is formed, for example, as shown in FIGS. 17 and 18. In a case where it is formed as a modified cross section (cross section other than a circular cross section, for example, Y-shape, star-shape, cross-shape and triangular-shape sections), the spinning hole is formed, for example, as shown in FIGS. 19 and 20.

FIG. 17 or 19 shows a part of the vertical section of a disc member 101 or 111 constituting a nozzle plate for spinning, and a predetermined number of spinning holes 102 or 112 are formed in the disc member 101 or 111. The arrows indicate the flow direction of a molten fluid, for example, a molten synthetic resin. Each of the spinning holes 102 or 112 comprises a fluid-introducing opening 103 or 113 whose cross section is formed as a circular cross section and whose inner surface is formed as a tapered surface, a fluid-introducing portion 104 or 114 formed as a right-cylindrical hole whose cross section is formed as a circular cross section, a contracting portion 105 or 115 whose cross section is formed as a circular cross section and whose inner surface is formed as a tapered surface, and a fluid-discharging portion 106 or 116 having a constant radial cross-sectional shape along the axial direction thereof. For use in spinning a circular cross-section yarn, the cross section of the fluid-discharging portion 106 is formed with a circular section as shown in FIG. 18, and for use in spinning a modified cross-section yarn, the cross section of the fluid-discharging portion 116 is formed with, for example, a Y-shape cross section as shown in FIG. 20.

An extremely high finishing accuracy is required for processing the fluid-discharging portion 106 or 116 in the spinning hole 102 or 112 and additionally the hole diameter (the maximum hole diameter) must be processed to a small diameter in the range of about 0.1 to 1.0 mm. In particular, in the case of a nozzle plate for a modified cross-section yarn, the cross section of the hole portion must be formed as a modified cross section. Because of the need for such high accuracy the fluid-discharging portion 106 or 116 is usually formed by electric discharge machining. Thus, the portion down to the contracting portion 105 or 115 is formed by, for example, drilling and finished by, for example, reaming, and the fluid-discharging portion 106 or 116 is processed by electric discharge machining.

In the conventional nozzle plates whose spinning holes 102 and 112 are formed by such a process, however, there are the following problems.

In the nozzle plate for a circular cross-section yarn shown in FIGS. 17 and 18, because the vertical sectional shape of the spinning hole 102 is provided by a broken line as shown in FIG. 17, it is difficult or impossible to obtain a smooth flow of a molten fluid particularly at a position where the cross-section of the hole suffers an abrupt change. This causes an increase of pressure loss, and as the case may be, a local residence of fluid is liable to occur.

Such a problem becomes greater in the nozzle plate for a modified cross-section yarn shown in FIGS. 19 and 20. Thus, in the production process, a flat surface portion 117 is inevitably formed at the entrance portion of the fluid-discharging portion 116, that is, at the boundary portion between the contracting portion 115 and the fluid-discharging portion 116, and this flat surface portion 117 remains after forming the fluid-discharging portion 116 as shown in the figures. Since the flat surface portion 117 is a surface almost normal to the flow direction of a molten fluid, a residence of the molten fluid is likely to occur on this portion. In addition, this portion causes a great pressure loss.

There is a fear that such a residence of the molten fluid causes difficulties during spinning such as cutting of a spun yarn and/or a deterioration in quality of the produced yarn. If the pressure loss increases, because a higher pressure is required at a position of the entrance of the nozzle plate, a higher pressure resistance is required for the nozzle plate, and further for parts provided upstream of the nozzle plate.

Further, in the aforementioned conventional processing, because the fluid-discharging portions 106 or 116 must be processed one by one by electric discharge machining, a considerable, detailed operation and a long time are required for the processing, the cost for manufacturing the nozzle plate increases, and a variation in the dimensional accuracy of the respective finished fluid-discharging portions 106 or 116 is likely to occur. If the variation becomes great, it causes problems in that the quality of the spun yarn is reduced and difficulties in its production arise.

It would be desirable to provide a nozzle plate for spinning having a plurality of spinning holes which can prevent undesired residence of a molten fluid in the spinning holes substantially completely and can suppress the pressure loss due to the spinning holes to an extremely low value.

Further, it would be desirable to provide a nozzle plate for spinning which can facilitate the processing of spinning holes, can shorten the time for plate manufacture to a great extent, and can allow manufacture of the plate at a low cost.

A nozzle plate for spinning according to the present invention having a plurality of spinning holes, and

each of the spinning holes comprises a fluid-introducing portion into which a molten fluid is introduced and a fluid-discharging portion having an inner diameter smaller than that of the fluid-introducing portion and from which the molten fluid sent from the fluid-introducing portion is discharged. The nozzle plate is characterized in that at least a part of the inner surface of each of the spinning holes, which is connected to an entrance of the fluid-discharging portion as viewed in the flow direction of the molten fluid, is formed as a three-dimensional curved surface indicating substantially no form line of the entrance of the fluid-discharging portion.

Namely, the inner surface of the spinning hole, which has been formed in a broken-line state as viewed in the vertical section of the hole in a conventional nozzle plate, is formed as a smoothly extending three-dimensional curved surface (a curved line in the vertical section) at least on a portion connected to the entrance of the fluid-discharging portion in the present invention. The three-dimensional curved surface is smoothly connected to the entrance of the fluid-discharging portion so that a line indicating a form of the entrance of the fluid-discharging portion does not appear.

Such a nozzle plate can be realized and manufactured, for example, by forming respective spinning holes in respective ceramic members and fixing the ceramic members in respective attachment holes formed on a nozzle body made of, for example, a metal disc member.

Namely, the nozzle body and the members for forming spinning holes are made as members different from each other, and both members are combined with each other. As the material used for the members for forming spinning holes, a ceramic is an optimum material from the viewpoints of heat resistance, pressure resistance and molding property. For example, the ceramic member having a spinning hole with a desired shape (the three-dimensional curved surface and other portions) can be obtained by preparing a pin-like mold having a three-dimensional curved periphery corresponding to the above three-dimensional curved surface, forming a ceramic member on the pin-like mold using ceramic powder (for example, by injection molding), and calcining the ceramic member. As needed, a processing for correction of the molded member may be added in order to further raise the dimensional accuracy of the spinning hole.

The above-described pin-like mold can be made, for example, by machining an appropriate steel material. Although a certain line indicating the outline of the pin-like mold may slightly appear on the mold in the stage of machining the mold, such a line can be easily removed by polishing the outer surface of the mold along the appeared line with an appropriate small pressure. When a ceramic member is molded on the pin-like mold thus obtained which has no form line on the outer surface, using ceramic powder, a desired three-dimensional curved surface indicating substantially no form line of the entrance of the fluid-discharging portion can be realized in the spinning hole formed in the molded ceramic member.

The ceramic members thus formed are inserted into and fixed in the attachment holes of the nozzle body, and a nozzle plate in accordance with the present invention can be obtained.

In the nozzle plate for spinning according to the present invention, since the inner surface of the spinning hole, particularly, the inner surface of the portion of the spinning hole which is reduced in diameter and connected to the entrance of the fluid-discharging portion, is formed as a three-dimensional smoothly curved surface and the curved surface is connected smoothly to the fluid-discharging portion so that a form line at the entrance of the fluid-discharging portion does not appear, a suddenly bent portion or a flat surface perpendicular to the flow direction of a molten fluid, as have been formed in conventional nozzle plates, is not formed. Therefore, a smooth flow of the molten fluid can be realized, the residence of the molten fluid in the spinning hole can be prevented, and the pressure loss due to the spinning hole can be greatly decreased by the smooth flow.

Although the present invention is effective, of course, for a nozzle plate for a circular cross-section yarn, particularly remarkable advantages can be obtained by application of the present invention to a nozzle plate for a modified cross-section yarn. Namely, in the application to a nozzle plate for a modified cross-section yarn, the flat surface having been formed immediately upstream of the fluid-discharging portion as shown in FIGS. 19 and 20, which may cause a local residence of a molten flow and a great pressure loss, completely disappears. Because of this, a residence of the molten fluid at this portion can be completely prevented. In addition, the molten fluid can flow extremely smoothly in spite of the contraction in diameter in the area of the three-dimensional curved surface, thereby greatly decreasing the pressure loss. As a result, the quality of the yarn spun by the nozzle plate according to the present invention can be greatly improved. Further, because the pressure loss due to the nozzle plate can be suppressed to a small value, the pressure load applied to the nozzle plate and parts upstream of the nozzle plate can be suppressed to a small value, and the pressure resistance can be greatly increased.

Furthermore, if the members for forming spinning holes are prepared separately from the nozzle body and made from a ceramic material and the members are fixed in the nozzle body, the spinning holes having a desired shape can be easily formed, and the nozzle plate can be manufactured in a short period of processing time at a low cost. This advantage for reducing the cost is more remarkable as the number of

the spinning holes increases, and in a case of a nozzle plate having several-thousand spinning holes, an extremely great cost-down advantage can be obtained.

Some preferred embodiments of the invention will now be described with reference to the accompanying drawings, which are given by way of example.

FIG. 1 is a plan view of a nozzle plate for spinning according to a first embodiment of the present invention.

FIG. 2 is a side view of the nozzle plate shown in FIG. 1, partially cut away.

FIG. 3 is an enlarged, partial, vertical sectional view of the nozzle plate shown in FIG. 1.

FIG. 4 is an enlarged plan view of a spinning hole of the nozzle plate shown in FIG. 3.

FIG. 5 is a partial, vertical sectional view of a nozzle plate, showing the shape of a spinning hole according to a modification of the first embodiment.

FIG. 6 is a partial, vertical sectional view of a nozzle plate, showing the shape of a spinning hole according to another modification of the first embodiment.

FIG. 7 is a schematic plan view of a spinning hole, showing an example of the changing state of the cross-sectional shape of the spinning hole at different respective axial positions along the spinning hole.

FIG. 8 is a schematic plan view of a spinning hole, showing another example of the changing state of the cross-sectional shape of the spinning hole.

FIG. 9 is a schematic plan view of another spinning hole.

FIG. 10 is a partial, vertical sectional view at a fluid discharging portion of a spinning hole.

FIG. 11 is a plan view of a fluid-discharging portion.

FIG. 12 is a plan view of another fluid-discharging portion.

FIG. 13 is a plan view of a further fluid-discharging portion.

FIG. 14 is a plan view of a nozzle plate for spinning according to a second embodiment of the present invention.

FIG. 15 is an enlarged, partial, vertical sectional view of the nozzle plate shown in FIG. 14.

FIG. 16 is an enlarged plan view of a spinning hole of the nozzle plate shown in FIG. 15.

FIG. 17 is a partial, vertical sectional view of a conventional nozzle plate.

FIG. 18 is an enlarged plan view of a spinning hole of the nozzle plate shown in FIG. 17.

FIG. 19 is a partial, vertical sectional view of another conventional nozzle plate.

FIG. 20 is an enlarged plan view of a spinning hole of the nozzle plate shown in FIG. 19.

FIGS. 1 to 4 show a nozzle plate for spinning according to a first embodiment of the present invention. In this embodiment, the present invention is applied to a nozzle plate for a modified cross-section yarn. In FIGS. 1 and 2, a nozzle plate 1 comprises a nozzle body 2 formed from a metal disc member and a plurality of (a predetermined number of) ceramic members 5 which are arranged at a predetermined pitch. The ceramic members 5 are fixed in respective attachment holes 3 provided in the nozzle body 2. Each ceramic member 5 has a spinning hole 4 therein for spinning a yarn using a molten fluid to be introduced.

The material of the nozzle body 2 is not particularly restricted, and any material can be used as long as it has heat resistance, pressure resistance and corrosion resistance required for a nozzle plate for spinning. Therefore, a stainless steel, which has been used in the conventional nozzle plates, can be employed. Further, although the nozzle body 2 is made as a metal disc member in this embodiment, it may be made from another material, for example, it may be made as a ceramic member molded separately from the ceramic members 5.

The material of the ceramic members 5 also is not particularly restricted. For example, a ceramic material including an alumina or a zirconia can be used as the material.

Among these materials, a zirconia-system ceramic having a high rigidity is preferred.

The ceramic member 5 has therein a spinning hole 4, and in this embodiment, the external periphery of the ceramic member 5 is formed as a stepped shape, as shown in FIG. 3. In an internal periphery of the nozzle body 2 defining an attachment hole 3 therein, a corresponding stepped portion 3a for fitting with the stepped ceramic member 5 is formed at a central position in the thickness direction of the nozzle body 2. Thus, ceramic member 5 can be inserted into attachment hole 3 so that the stepped external periphery of ceramic member 5 cooperates with the correspondingly stepped fitting portion 3a, so that the ceramic member 5 sits within the attachment hole 3 and forms a fit with the nozzle body 2. However, an upper portion 3b and a lower portion 3c of the internal periphery of the nozzle body 2 defining attachment hole 3 have respective diameters larger than those of the corresponding external peripheral portions of the ceramic member 5. Thus, after respective ceramic members 5 have been inserted into respective attachment holes 3, a heat-resistant inorganic adhesive 6 can be charged into respective spaces defined between the external peripheral portions of the ceramic members 5 and the inner surface portions of the respective external peripheries defining the attachment holes 3 and thereafter solidified (cured). By this charge and solidification of the heat-resistant inorganic adhesive 6, the ceramic members 5 are fixed strongly into the attachment holes 3 while the existence of spaces in which residence of fluid, both at the upper and lower surfaces can be prevented.

The heat-resistant inorganic adhesive 6 compris-

es, for example, a mixture of an inorganic powder such as glass powder or ceramic powder and a heat-resistant adhesive or a binder. Such a heat-resistant inorganic adhesive 6 is solidified by heat treatment in a furnace (for example, a constant temperature bath or a calcination furnace) after being charged.

Although the ceramic members 5 are fixed in the attachment holes 3 using the heat-resistant inorganic adhesive 6 in this embodiment, other methods may be employed for the fixing. For example, a method for forming the attachment holes 3 in a form substantially the same as that of the periphery of each ceramic member 5 over the entire length thereof and press-fitting the respective ceramic members 5 into the respective attachment holes 3, or a method for expanding the attachment holes 3 by heating the nozzle body 2, inserting the ceramic members 5 controlled at room temperature or heated at the same temperature as that of the nozzle body 2 into the heat-expanded attachment holes 3, and thereafter, reducing the temperature of the nozzle body 2 to fix the ceramic members 5 in the attachment holes 3, can be employed.

The spinning hole 4 defined in each ceramic member 5 is formed as a shape shown in FIGS. 3 and 4 in this embodiment. As shown in FIG. 3, the spinning hole 4 is formed from a fluid- entry port 7 into which a molten fluid (for example, a molten synthetic resin) is introduced and whose radial cross section is formed as a circle and whose inner surface is formed as a tapered surface, a fluid- conduit portion 8 which is connected to the fluid- entry port 7 and is formed as a right-cylindrical portion having a circular cross section, a three-dimensionally curved surface portion 9 which is connected to the fluid- conduit portion 8 and has a three-dimensional smoothly curved surface and the diameter of which becomes smaller as it extends downstream, and a fluid- exit port 10 which is connected to the three-dimensional curved surface portion 9, discharges the molten fluid and is formed as a fluid-discharging portion having a modified cross section of constant diameter along its axial length.

The modified cross section of the fluid-discharging portion 10 is formed as a Y-shape cross section in this embodiment, as shown in FIG. 4. The surface form of the three-dimensional curved surface portion 9 changes smoothly, and it is smoothly connected to an entrance 10a of the fluid-discharging portion 10 so that the form line of the entrance 10a of the fluid-discharging portion 10 substantially does not appear. In FIG. 3, although the boundary lines between the respective hole portions are depicted by broken lines in order to facilitate the explanation, these lines do not appear in practice. In this embodiment, the boundary between the three-dimensional curved surface portion 9 and the fluid- conduit portion 8 is also in a condition such as to provide a connection via a smooth curved surface, and a form line also does not appear in this portion. Further, in this embodiment, the boundary between the fluid-entry port 7 and the fluid- conduit portion 8 is also formed as a curved surface (a surface with a small roundness), and the surfaces thereof are smoothly connected for smooth fluid transfer also in this portion.

The shape of the modified cross section of the fluid-discharging portion 10 is not limited to the above-described Y-shape. Various shapes applied for known modified cross-section yarns, for example, star-shape, cross-shape and triangular-shape, can be employed. In any cross-sectional shape, at least a fluid- conduit portion and a fluid-discharging portion may be smoothly connected by a three-dimensional curved surface portion such that a form line of an entrance of the fluid-discharging portion does not appear.

With respect to the fluid-discharging portion 10, usually the hole diameter (the maximum diameter) thereof is in the range of about 0.1 to 1.0 mm, and the length thereof is in the range of about 0.1 to 1.0 mm. As to the fluid- conduit portion 8, the hole diameter thereof is usually in the range of about 1.0 to 5.0 mm. In conventional technology, the fluid-discharging portion is processed only by electric discharge machining, because the hole diameter is small and a high accuracy is required, as aforementioned. In this embodiment of the present invention, however, since ceramic members 5 prepared separately from the nozzle body 2 are used as members for forming spinning holes 4, the ceramic members 5 can be manufactured in a short period of time and at a high accuracy in a substantially identical process by the following method.

Namely, a pin-like mold having substantially the same peripheral shape as the shape of the spinning hole 4 is prepared. Using the pin-like mold, a ceramic member is molded around the pin-like mold using ceramic powder (or a mixture of ceramic powder and a binder), and as needed, a detailed finishing may be applied. Thus, a ceramic member 5 having a spinning hole with a desired shape at a high accuracy can be obtained.

In the above embodiment, the molten fluid flowing from the fluid- conduit portion 8 to the fluid-discharging portion 10 flows along the three-dimensional curved surface portion 9. Since the three-dimensional curved surface portion 9 is smoothly connected to the fluid-discharging portion 10 having a Y-shape modified cross section so that the form line of the entrance 10a of the fluid-discharging portion 10 does not appear, the flow from the fluid- conduit portion 8 to the inside of the fluid-discharging portion 10 can have an extremely smooth stream line. Namely, because a broken-line like flow present in the conventional spinning hole is not formed, particularly because a flat surface portion as shown in FIGS. 19 and 20 is not at all formed at a position upstream of the fluid-discharging portion 10, portions causing residence of fluid completely disappear, and

the pressure loss can be greatly decreased by the smooth flow.

Further, in this embodiment, since the boundary portion between the fluid-entry port 7 and the fluid-conduit portion 8 and the boundary portion between the fluid-conduit portion 8 and the three-dimensional curved surface portion 9 are also formed as smooth curved surfaces, smooth flow can be realized also in these portions, thereby further reducing the pressure loss.

Furthermore, since the ceramic members 5 each having the spinning hole 4 can be produced easily at a high accuracy and in large scale numbers separately from the production of the nozzle body 2, the nozzle plate 1 can be inexpensively manufactured in a short period of time.

Although the length of the three-dimensional curved surface portion 9 is relatively short in the flow direction of the molten fluid in the above-described embodiment, the length may be appropriately changed. For example, the three-dimensional curved surface portion 9 may be formed from a central portion of the fluid- conduit portion 8 as viewed in the axial direction, and the three-dimensional curved surface portion 9 may be formed as a relatively long surface and connected to the fluid-discharging portion 10.

Further, as shown in a modification depicted in FIG. 5, a three-dimensional curved surface portion 11 may be formed over the entire length from the entrance of the fluid- entry portion (that is, the exit of the fluid- entry port 7) to the fluid-discharging portion 10. Furthermore, as shown in another modification depicted in FIG. 6, a three-dimensional curved surface portion 12 may be formed over the entire length from the entrance of the fluid- entry port (that is, the entrance of the nozzle plate) to the fluid-discharging portion 10. In these embodiments shown in FIGS. 5 and 6, the cross-sectional shape of the hole may be formed as a modified cross-sectional shape having a similar configuration throughout the axial length. Thus, the cross-sectional shape of the fluid-discharging portion may have a configuration which is the same as, or close to,that of the entrance of the fluid-conduit portion, and further that of the entrance of the fluid-entry port. Still further, although the form line of the three-dimensional curved surface portion indicated in the vertical section is defined as a curved line, the three-dimensional curved surface portion may be formed such that the form line in the vertical section is defined as a straight line or a line close to the straight line.

The length and the curved condition (for example, the degree of change of the cross-sectional shape in the axial direction) of the three-dimensional curved surface portion 9, 11 or 12 may be appropriately designed depending upon various factors such as the viscosity of the molten fluid, the affinity of the molten fluid with the member for forming the spinning hole and the spinning speed.

For instance, FIGS. 7 and 8 show examples of how the cross-sectional shape of the spinning hole may change in the axial direction (in the flow direction of the molten fluid). In the example shown in FIG. 7, the cross-sectional shape of a spinning hole 13 is that of a circle 13a at the entrance portion of the fluid- entry port, it gradually changes to modified cross-sectional shapes 13b, 13c and 13d in order as it approaches the fluid-discharging portion, and it is that of a predetermined Y-shape 13e at the fluid-discharging portion. In the example shown in FIG. 8, although the cross-sectional shape of a spinning hole 14 is that of a circle 14a at the entrance portion of the fluid-entry port, it is rapidly changes to a modified cross section 14b immediately after the entrance portion. Then, the cross-sectional shape changes to a modified Y-shape cross sectional shape 14c relatively rapidly, and is connected to the Y-shape cross sectional shape 14e through the Y-shape cross sectional shape 14d of a configuration similar to that of the shape 14c. Although the lines expressing respective cross-sectional shapes are depicted in FIGS. 7 and 8 only for explanation, these lines other than those of the entrances of the spinning holes and the fluid-discharging portions do not appear in practice.

Further, FIG. 9 shows a further example of a spinning hole 15. In this example, protruding portions 15a, 15b and 15c are formed on the inner surface of the spinning hole 15, and they become gradually enlarged as they approach the fluid-discharging portion to form a predetermined cross-sectional Y-shape 15d at the entrance of the fluid-discharging portion. Again in this example, although the lines indicating the protruded portions 15a, 15b and 15c are depicted only for explanation, they do not appear in practice.

Although various shapes for a spinning hole have been explained above, in a case where a higher accuracy is required in the cross-sectional shape of a spun yarn, there is a fear that the following problem occurs.

FIG. 10 shows an example of a vertical section of a fluid-discharging portion 16 and a three-dimensional curved surface portion 17. The modified cross section is gradually developed in the flow direction of the molten flow shown by the arrows in the area of the three-dimensional curved surface portion 17, particularly in the area near the entrance of the fluid-discharging portion 16. Therefore, the molten fluid enters into the modified cross-sectional portion (for example, Y-shape portion) from different positions, as shown by the stream lines F1 and F2. In such a flow condition, the flow paths L1 and L2 down to the exit of the fluid-discharging portion 16 in the modified cross-sectional portion are different from each other. If the modified cross-sectional shape of the fluid-discharging portion 16 is a Y-shape 18a as shown in FIG.

11 and an extending portion 18b of the Y-shape 18a extending in the radial direction of the fluid-discharging portion 16 has a constant width "W", the flow rate of a portion nearer the central portion of the cross section becomes greater than that of a portion farther from the central portion, originating from the difference between the pressure losses which is caused by the difference between the flow paths such as the difference between L1 and L2. As a result, the cross section of the spun yarn is likely to be deformed as shown by the dashed line 18c.

In order to prevent such a deformation, the following methods, wherein the width of a portion defined in the modified cross section and extending in the radial direction of the fluid-discharging portion is changed in the radial direction of the fluid-discharging portion, are effective.

For example, as shown in FIG. 12, the width W1 of an extending portion 19b of a modified cross section 19a is almost linearly changed in the area "B" corresponding to the area "A" shown in FIG. 10 so that the width W1 becomes gradually smaller as the central portion of the modified cross section 19a is approached. This method is particularly effective in a case where the vertical sectional line of the three-dimensional curved surface 17 is formed almost as a straight line in the area "A". In FIG. 13, the width W2 of an extending portion 19d of a modified cross section 19c changes, as represented by curved lines in the area "C" corresponding to the area "A" shown in FIG. 10, so that the width W2 becomes gradually smaller as the central portion of the modified cross section 19c is approached. This method is particularly effective in a case where the vertical sectional line of the three-dimensional curved surface 17 is formed as a curved line in the area "A". Even if there is a difference between the flow paths such as the difference between L1 and L2, the difference between the flow rates at the exit of the fluid discharging portion 16 can be suppressed to a small value by such methods, and the deformation of the cross section of the spun yarn can be suppressed.

FIGS. 14 to 16 show a nozzle plate for spinning according to a second embodiment of the present invention. In this embodiment, the present invention is applied to a nozzle plate for a circular cross-section yarn. A nozzle plate 20 comprises a nozzle body 21 constructed from a metal disc member and a predetermined number of members 22 for forming spinning holes which are also constructed from ceramic members, similarly to those in the first embodiment. The ceramic members 22 are fixed to the nozzle body 21 in a manner similar to that of the first embodiment.

A spinning hole 23 is formed in each ceramic member 22, and the spinning hole 23 comprises a fluid-entry port 24, a fluid-conduit portion 25, a three-dimensional curved surface portion 26 (tapered portion) and a fluid-discharging portion 27. The fluid-discharging portion 27 has a circular cross section, and the fluid-entry port 24, the fluid-conduit portion 25 and the three-dimensional curved surface portion 26 also have circular cross sections, respectively. The three-dimensional curved surface portion 26 is smoothly connected to the fluid-discharging portion 27 so that a form line of an entrance 27a of the fluid-discharging portion 27 does not appear.

Even in such a nozzle plate for a circular cross-section yarn, because the inner surface of the hole connected to the fluid-discharging portion 27 is formed as the three-dimensional smoothly curved surface portion 26, no broken-line portion occurs particularly at the portion of the entrance 27a of the fluid-discharging portion 27, and an extremely smooth flow of the molten fluid can be obtained. As a result, a portion causing a residence of the molten fluid and a portion causing a great pressure loss do not appear, and in spite of the constriction of the hole to a small diameter, an extremely smooth flow and a low pressure loss can be achieved.

Also in this embodiment, modifications similar to those shown in FIGS. 5 and 6 can be applied, and the shape and length of the three-dimensional curved surface portion 26 can be appropriately designed depending on various requirements.

Although the molten fluid applied in the present invention is not particularly restricted as long as it can be spun, the nozzle plate according to the present invention is suitable particularly for spinning a synthetic fiber yarn represented by nylon and polyester yarns, that is, a nozzle plate for spinning at a relatively low pressure. In the production of a regenerated fiber represented by a rayon or a semi-synthetic fiber represented by an acetate fiber, a nozzle plate having a relatively small thickness (for example, a simple nozzle plate formed by punching holes on a plate with a thickness of about 1 mm) is frequently used. Even for such fibers, however, in a case where a relatively thick nozzle plate is used, the present invention can be applied.

According to one particular aspect, the invention provides a nozzle plate for spinning comprising a nozzle plate body having at least one aperture passing therethrough and secured within the or each aperture a or a respective spinning nozzle, the or each spinning nozzle having a spinning hole passing therethrough, which spinning hole is defined by a profiled internal periphery of the spinning nozzle, which profile is such as to provide a fluid discharging portion of the spinning hole at a discharging end region of the spinning nozzle and, upstream of the discharging end portion, a fluid conduit portion at a fluid conduit region of the spinning nozzle, the spinning hole having a cross-sectional area in the discharging end region which is smallest and which is smaller than that in the fluid conduit region and the profile of the internal periphery of the spinning nozzle including a portion, at

least between the fluid conduit portion and the discharging end portion, which in the flow direction is three-dimensionally curved such as to provide a spinning hole which continuously converges from the fluid conduit region to the discharge end region in which the cross-sectional area of the spinning hole is smallest.

In this manner, the profile thus exhibits no discernible sudden change in cross-sectional dimension in the flow-direction, at least between the fluid-conduit region and the fluid-discharging end region. Preferably, there is no discernible sudden change, as would be evident, for example, from a visible circumferential demarkation line, in cross-sectional dimension throughout the entire length of the spinning hole.

Claims

1. A nozzle plate for spinning having a plurality of spinning holes, each of said spinning holes comprising a fluid-introducing portion into which a molten fluid is introduced and a fluid-discharging portion having an inner diameter smaller than that of said fluid-introducing portion and from which said molten fluid sent from said fluid-introducing portion is discharged, characterized in that at least a part of the inner surface of each of said spinning holes, which is connected to an entrance of said fluid-discharging portion as viewed in the flow direction of said molten fluid, is formed as a three-dimensional curved surface indicating substantially no form line of said entrance of said fluid-discharging portion.

2. The nozzle plate for spinning according to claim 1, wherein the cross section of said fluid-discharging portion is formed as a modified cross section.

3. The nozzle plate for spinning according to claim 2, wherein the width of a portion defined in said modified cross section and extending in the radial direction of said fluid-discharging portion is changed in the radial direction of said fluid-discharging portion.

4. The nozzle plate for spinning according to claim 1, wherein the cross section of said fluid-discharging portion is formed as a circular cross section.

5. The nozzle plate for spinning according to any preceding claim, wherein said plurality of spinning holes are formed in respective ceramic members and said respective ceramic members are fixed in respective attachment holes which are formed on a nozzle body of said nozzle plate.

6. The nozzle plate for spinning according to claim 5, wherein each of said ceramic members are fixed by charging a heat-resistance inorganic adhesive into a space between the periphery of each of said ceramic members and the inner surface of each of said attachment holes and solidifying said inorganic adhesive.

7. The nozzle plate for spinning according to any preceding claim, wherein said three-dimensional curved surface is formed substantially over the entire length of a portion of each of said spinning holes extending down to said entrance of said fluid-discharging portion in the axial direction of each of said spinning holes.

8. The nozzle plate for spinning according to any preceding claim, wherein the cross section of each of said spinning holes is formed as a modified cross section substantially over the entire length of each of said spinning holes in the axial direction of each of said spinning holes.

FIG. 1

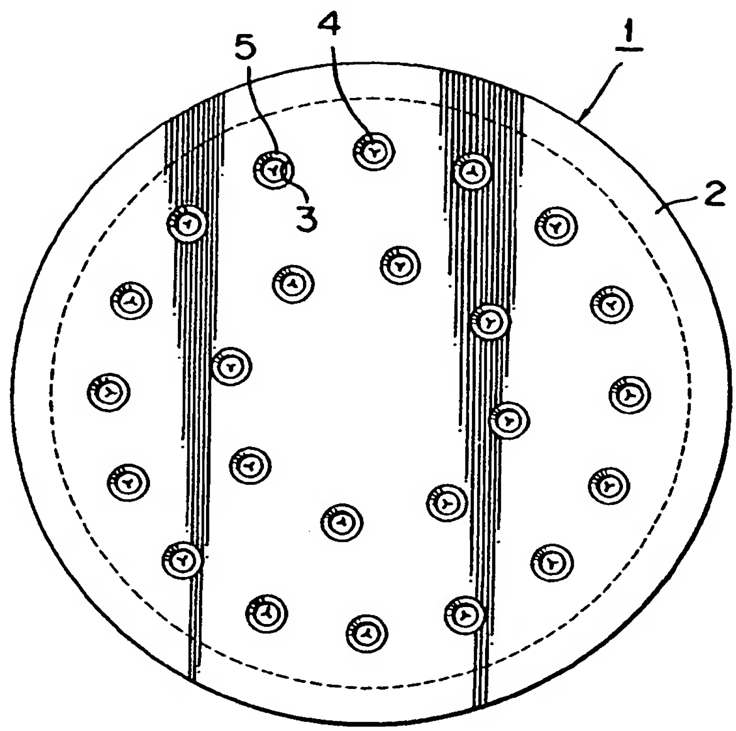


FIG. 2

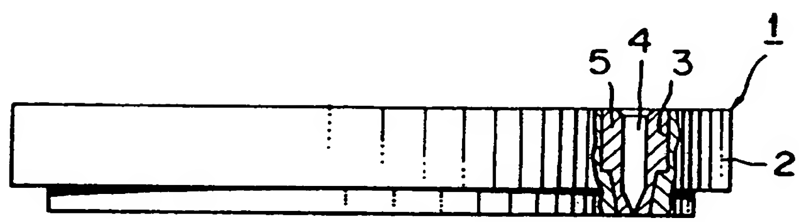


FIG. 3

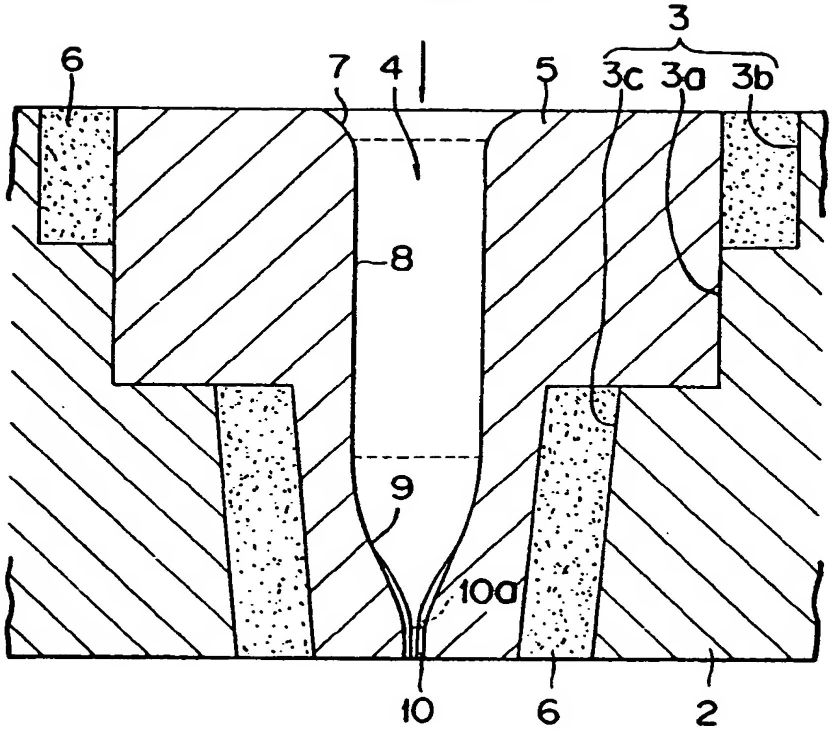


FIG. 4

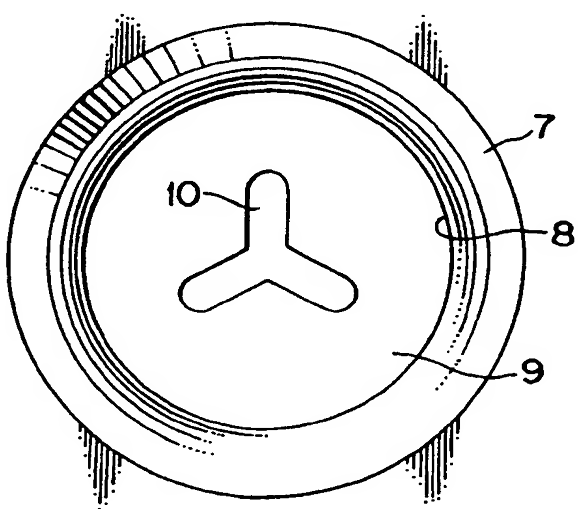


FIG. 5

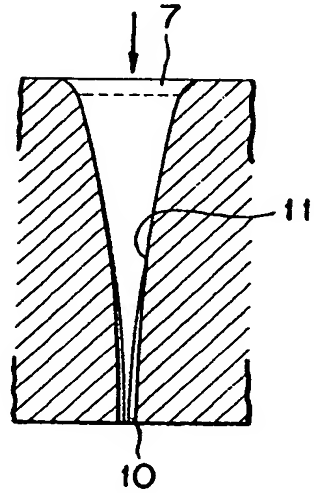


FIG. 6

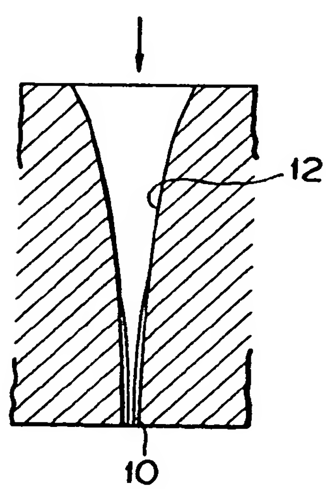


FIG. 7

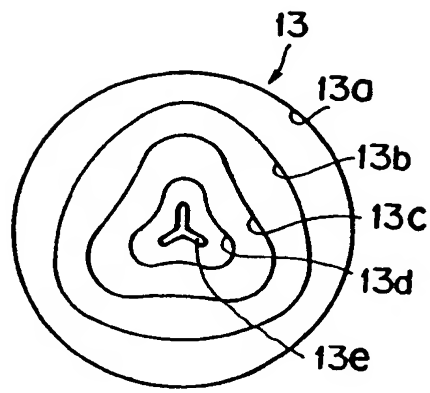


FIG. 8

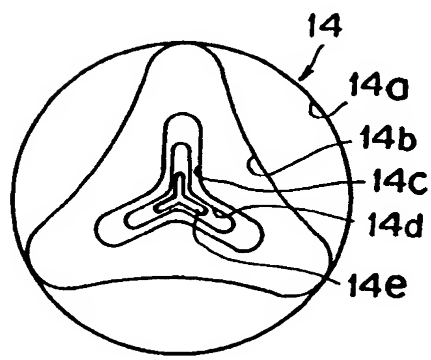


FIG. 9

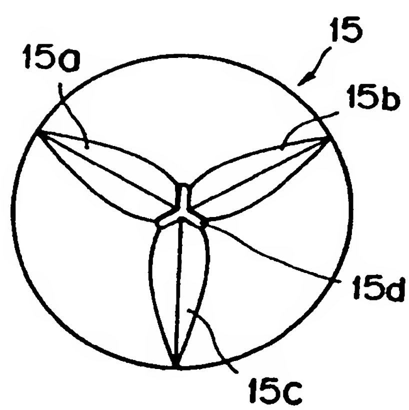


FIG. 10

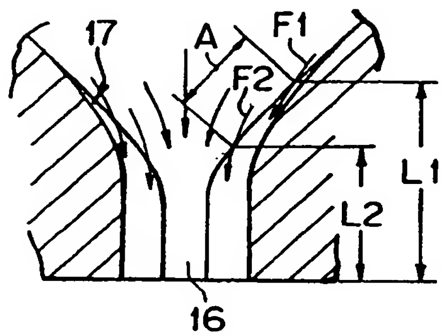


FIG. 11

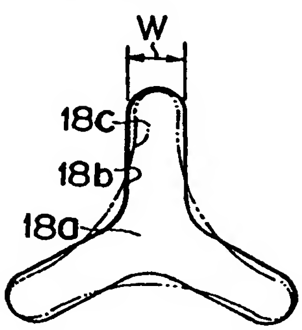


FIG. 12

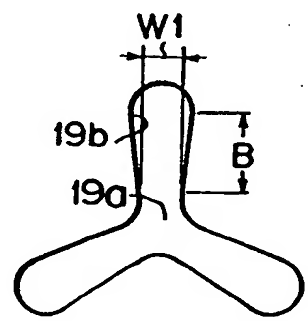


FIG. 13

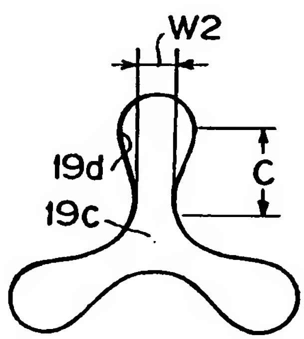


FIG. 14

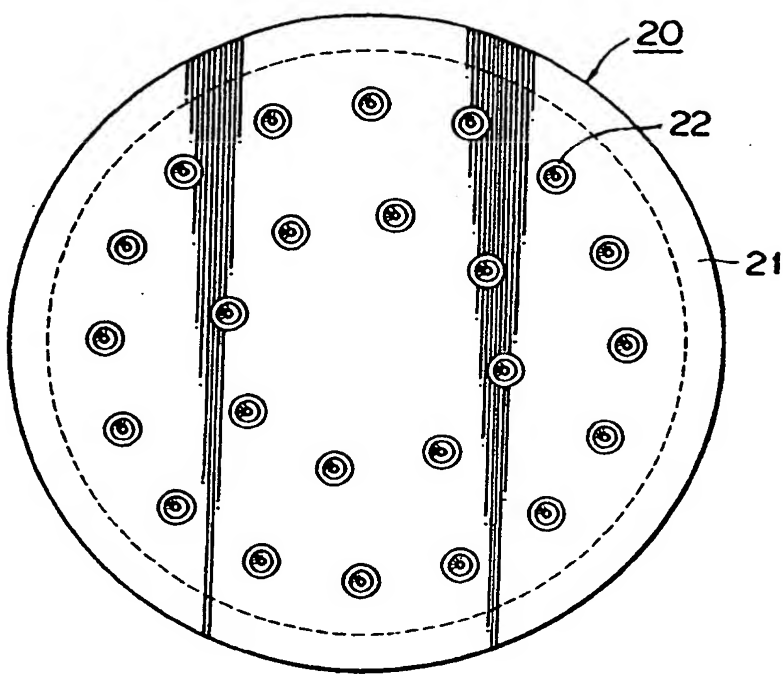


FIG. 15

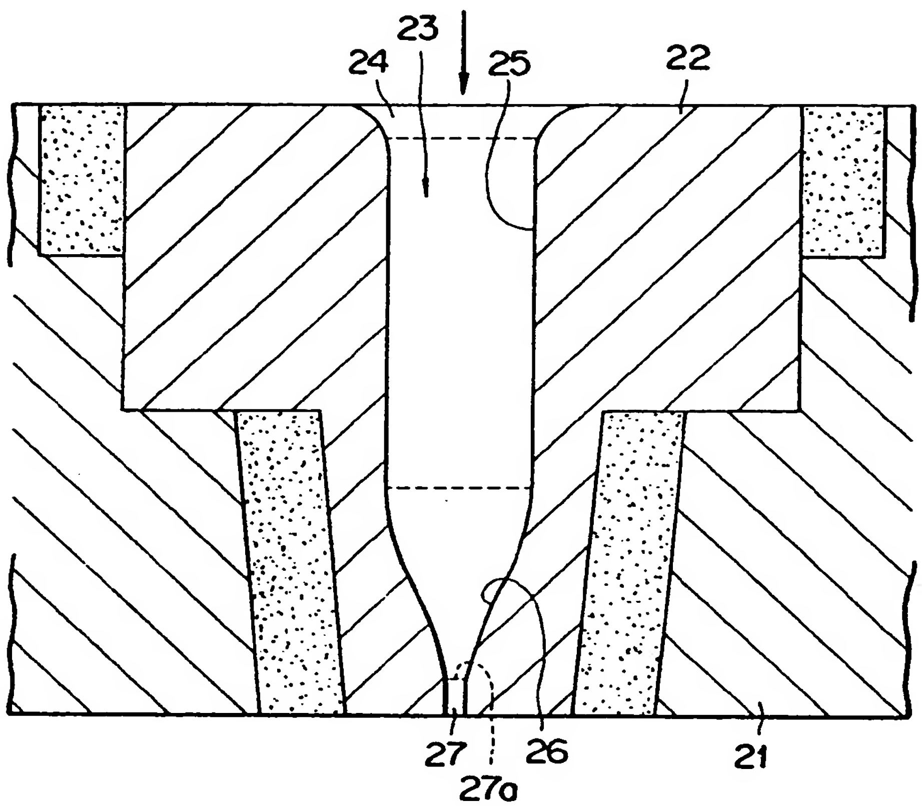


FIG. 16

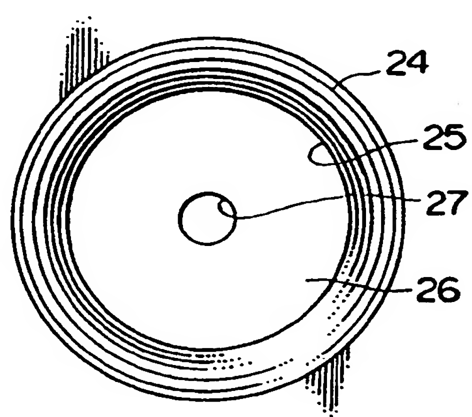


FIG. 17
PRIOR ART

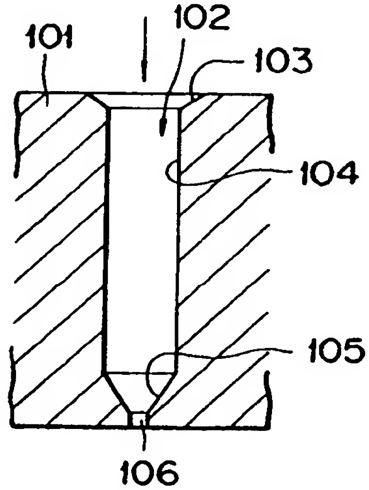


FIG. 18
PRIOR ART

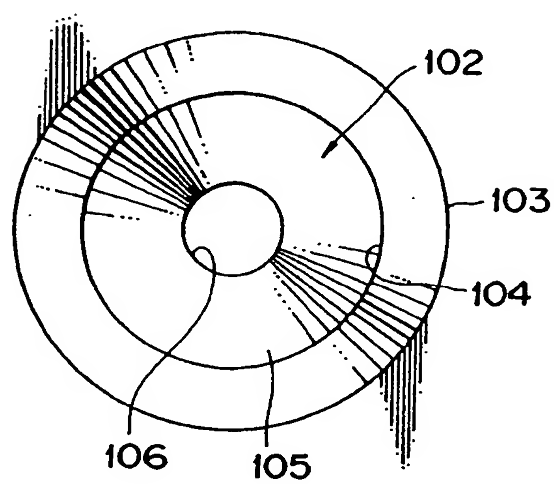


FIG. 19
PRIOR ART

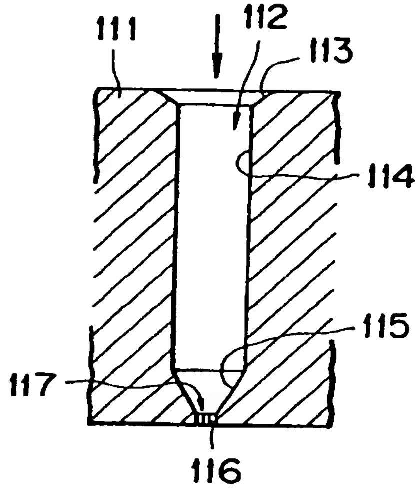
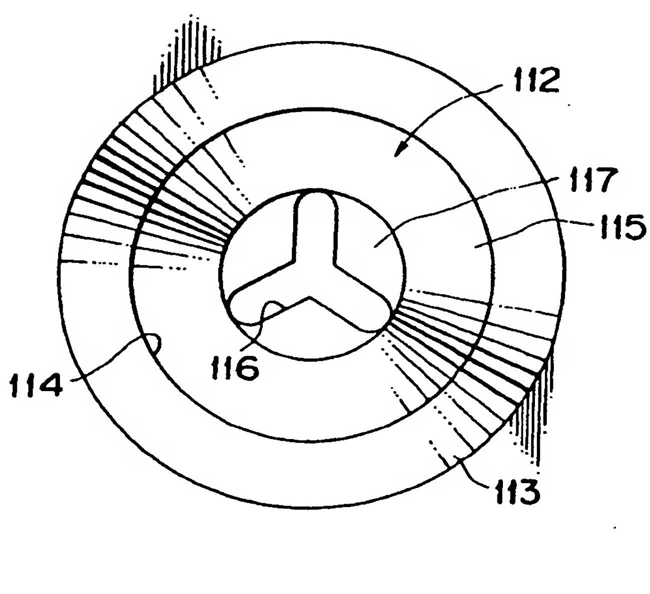


FIG. 20
PRIOR ART



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 8966

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	US-A-2 879 676 (MAX BURKHARDT ET AL.) * the whole document * ---	1-4,7,8 5,6	D01D4/02 D01D5/253
X Y	CH-A-540 996 (DR. PETER LIEGER) * the whole document * ---	1-4,7,8 5,6	
X Y	GB-A-734 521 (BAKER PLATINUM LIMITED) * the whole document * ---	1,4,7 5,6	
X Y	US-A-4 015 924 (HERMAN L. LANIEVE) * the whole document * ---	1,4,7 5,6	
X Y	US-A-3 210 451 (JOHN ALBERT MANNING, JR. ET AL.) * the whole document * ---	1,4,7 5,6	
Y	GB-A-1 126 609 (E.I. DU PONT DE NEMOURS AND COMPANY) * the whole document * ---	5,6	
A	US-A-3 001 230 (IRVING ROSSI) ---		TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US-A-3 303 530 (JAMES STANLEY COBB) -----		D01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 March 1995	Tarrida Torrell, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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